rust'), Madison™ rose ('Poulrijk'), Knockout™ rose ('RADrazz'), Fire Meidiland™ rose ('Meipsidue'), Mystic Meidiland™ rose ('Meialate'), and Red Fairy™ polyantha rose ('Moredfar'). However, many of the above cultivars are not recommended due to their high disease susceptibility [Cambridge™ rose ('Poulrust'), Madison™ rose ('Poulrijk'), Red Fairy™ polyantha rose ('Moredfar'), and Robusta™ rugosa hybrid rose]. Unfortunately, the roses, which produced the best flower display with high pest resistance often, were not winter hardy. Hip production occurred on many of the cultivars, however, only Carefree Beauty™ rose, 'Marie-Victorin', and Mystic Meidiland™ rose produced colorful orange-red hips. Hip production in the northern location of Spooner was poor as many of the cultivars, including Carefree Beauty™ rose, 'Marie-Victorin', and Mystic Meidiland™ rose only produced green hips and did not have sufficient time to change colors to orange or red before a severe frost occurred thereby turning the hips black.

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A Brief Discussion of Rooted Cutting Propagation at Mitsch Nursery With Focus on Conifers©

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BRIEF HISTORY

I have been asked to discuss methods of rooting "difficult-to-root" conifers at Mitsch Nursery. Let me start by explaining a few things about the nursery history and how our program has evolved, as that may give more insight into how some of our methods were developed, than any of the actual formulas.

Mitsch Nursery began as a project of a few trays of plants on the sun porch of the small Arts and Crafts-inspired house that now houses the nursery office. John left school in the 8th grade, and with his parents' help, began to sell rooted cuttings that he had propagated. Little by little his project required more space, until he eventually bought the property from his father, and ran Mitsch Nursery for over 40 years. The industry was young, and he was able to develop relationships with like-minded plant's people all over the country in order to acquire, trial, and disseminate new ornamental plants.

It is interesting and important to note here that neither John Mitsch himself, or any of his employees had any formal training in horticulture. They were deeply committed plant lovers who were willing to glean whatever information they could from other nurserymen and from extension and arboretum researchers, and to try different ideas until they found what worked most dependably for their situation. There were no preconceived ideas about what "should" work.

Although John's initial attraction was to flowering and miniature shrubs, he also pioneered work with conifers, including *Juniperus*, dwarf *Picea abies* and *P. glauca*,

and *Pinus mugo*. He was best known for his huge collection of *Chamaecyparis* species and *Tsuga* species. They are a mainstay of our production still.

Bob and Dianne Fincham purchased Mitsch Nursery from John Mitsch in 1987–1988, and operated it until the fall of 1992. Bob brought to the nursery perhaps as many as 1000 cultivars of various coniferous species, and expanded the nursery operation to include grafted liners in addition to the rooted cuttings. Today our grafted stock comprises more than 50% of the annual income of the nursery. Bob's work in establishing and supporting the Conifer Society has united a worldwide group of enthusiasts, and has helped to create a continuing market for unusual grafted and rooted conifers.

Bill Vander Zalm of Ladner, British Columbia, is the current owner of Mitsch Nursery. His most notable contribution to our production has been the addition of over 50 cultivars of lilacs to the rooted cutting roster. As a Canadian political and business figure as well as the owner of Van's Nursery in British Columbia, he leaves management of Mitsch Nursery to me, and production of the rooted cuttings to our propagator, Martin Esquivel. Martin and I both continue the Mitsch Nursery tradition of being plant lovers rather than educated horticulturists, and depend more on consistent adherence to what has already been proven to work in our specific greenhouse environment than on new research.

CUTTING PROPAGATION ROUTINE

Our process for creating rooted cuttings is perhaps unique, and bears mention.

Cutting material is gathered in the morning and brought into the cutting room. As cuttings are completed, they are counted, and if a liquid hormone dip is required, they are dipped at that time. They are then deposited into plastic milk crates that have been lined with a 1/4 inch mesh screen to keep cuttings from falling through the crate openings. Crates are submerged briefly into a bath containing 8 oz chlorine bleach to 15 gal of water, allowed to drain, and then submerged into a second bath containing 4 oz of Cleary 3336 to 15 gal of water. We have chosen Cleary 3336 because it is a very broad-spectrum fungicide, but carries a "Caution" label, which is the lowest toxicity label available for registered pesticides. Thus, there is less danger of exposure for our employees, and less cumbersome requirements for PPE during use.

The cuttings are transferred into small bins, covered with burlap, and deposited in the cooler. We make cuttings Monday through Thursday with the prepared cuttings accumulating in the cooler. On Friday, the bins of cuttings are carried to the greenhouse worktable, near the rooting beds. Anderson propagation flats, already prepared with the appropriate rooting media, are supplied to workers at the table and are removed directly to the greenhouse beds when they have been filled. The entire crew, regardless of work assignment at other times, works together to stick the week's cuttings. If a powdered rooting compound is required, it is applied at this time, while the cuttings are being stuck.

This routine apparently evolved in an effort to enhance efficiency of labor and to reduce lifting and carrying of filled flats. Workers enjoy heat or air conditioning in the cutting room during the week, and lightweight bins of cuttings are carried from the cutting room to the greenhouse once instead of either making several treks a day, or trailering the heavy filled flats.

We're often questioned about rinsing the cuttings after they have been treated with liquid rooting compounds. We feel that the rooting compound has accomplished

its purpose very quickly after contact, and rinsing in the chlorine and the 3336 may remove any possibility of damage caused by prolonged contact with unevaporated remnants of denatured alcohol in the dip. Also, Wood's Rooting Compound, now carries a Worker Protection REI of 24 h, and storage in the cooler coincidentally satisfies this important safety regulation before the cuttings are handled again to stick in media.

There are two propagation greenhouses. The winter house is 120 × 170 ft. Bottom heat is delivered by pumping hot water from a boiler through 1/2-inch PVC pipe set into the gravel footing. Beds are 5 Anderson propagation flats wide and the PVC is set every 2 inches under the beds. A boiler and circulation pump provides bottom heat of about 72 °F. The house is equipped with a rudimentary mist system in which high-pressure nozzles on the north wall spray along the north walkway, and exhaust fans in the south wall draw the humidity through the house. There is a fog system that dates to the 1960s, but it is unreliable. Through trial and error, Martin has found that he prefers to cover unrooted cuttings with a lightweight spun-bonded agricultural cloth laid directly over the flats to retain warmth and humidity on the cuttings. He and the crew remove the cloth periodically throughout the rooting period to run the overhead irrigation. This is about once every 2 weeks when day temperatures remain in the 40s, and once a week as rooting begins to occur, and the weather warms up. In a cool environment, a water film need not be maintained on the cuttings the way it must in summer, as long as the air remains humid. The floating cover cloth provides an easy and timesaving propagation tool. I should note here that we have no way of heating the air in this greenhouse aside from the heat that escapes from the bottom heat through the cutting flats. Our winters are mild enough, and the area of bottom heat is large enough that air temperatures are maintained above freezing. I would have to say that we have more trouble exhausting heat during early springs than with keeping warm enough in the winter.

The summer greenhouse is 120 × 120 ft with only half actually used for propagation. We run no bottom heat in the summer, and send only enough bottom heat over from the boiler from December through February to keep cuttings that were rooted the previous summer from freezing. The southern exposure of this house provides for air temperatures up to and sometimes over 100 °F with 100% humidity when new crops are being loaded into the house in summer. The "mist system" is irrigation risers with standard spinner-type irrigation heads. A multiple station timer and solenoid system works in partnership with a Mist-A-Matic mechanical leaf to control the amount of moisture applied. During the height of summer, the spinners are activated for about 4 sec every 4 min, and Martin makes adjustments as he sees fit earlier in the spring and later in the fall, when temperatures aren't as intense. The Mist-A-Matic opens the electrical connection between the timer and the solenoids, delaying the next misting cycle if there is excessive moisture.

Timing and Treatment. Our propagation calendar begins in late April, and continues uninterrupted until the first week of the following March. The first conifer on the list is *P. mugo*. New buds are mature enough to make cuttings about mid-July. This is a difficult crop for us, occasionally sitting through the summer, fall, and winter before finally establishing roots the following spring. It isn't forgiving of being cut later in the season, and does exhibit declining rooting success when cut from aging stock. It is also notorious for growing just one root, which isn't acceptable for saleable plants. Although stripping needles from the bottom 1/2 inch of stem should serve to wound the stem, these virtually always callus at the bottom and root from the callus.

Chamaecyparis pisifera, *C. obtusa*, *Cryptomeria japonica*, *J. squamata* 'Blue Star', and *J. communis* cultivars are propagated in the summerhouse if we are able to get them in during early September. If we are running late, then we continue those crops during January and February over bottom heat in the winter house. The rooting is stronger if they are done in summer, but conditions are more difficult to balance to avoid over-misting, and to second-guess the weather for rooting to occur before it is too cool in fall. Remember, this house isn't heated for propagation. Sometimes the same crop, propagated over bottom heat in January, will root faster and grow earlier in the spring than early fall crops that were stuck just a bit too late and left dependent on a mild fall.

During October, we place *Thuja* and *Platycladus* cuttings in beds in the winter house. October is usually a month of temperatures in the high 50s to low 60s for us, and rarely cold enough to freeze at night. *Thuja* and *Platycladus* cuttings benefit from a cool callusing period during this time. The boiler is fired up for bottom heat in November, and work proceeds with the easier-to-root *C. pisifera* and *C. thyoides* cultivars, and then any remaining *C. obtusa*, *Juniperus*, *Microbiota*, and miscellaneous evergreen broadleaf shrubs are produced.

Taxus, *Cephalotaxus*, *Podocarpus*, *Picea,* and *Tsuga* fill out the calendar for mid-January until the first week of March. By mid-February, Willamette Valley weather can be very unpredictable, and we must be prepared to protect these crops from severe cold as well as early spring sunshine that can wreak havoc in the greenhouse. Our main concern is to keep the tops of the coniferous cuttings cool while the bottom heat keeps the flats warm, so that rooting can occur before the buds start to push.

We have found that dwarf spruce and hemlock cuttings perform more readily if cuttings are made from lateral growth. We do stick the leaders, but never have as successful a percentage as with the laterals. While some of our hemlocks must be cut down in order to make a manageable length for sticking, dwarfer cultivars do seem to benefit from being pulled from the shoot with a bit of a heel. We treat reluctant rooters, the *C. obtusa*, ×*Cupressocyparis leylandii*, a few *Juniperus*, *P. mugo*, *Taxus baccata*, and the *Tsuga* species with a "double dip" of medium-strength rooting compounds rather than a single high-strength treatment of either the liquid or the talc.

In our "double dip" method, cuttings are dipped in a Wood's Rooting Compound 1 : 10 dilution while they are being made in the cutting room. After rinsing in the chlorine and fungicide baths and being held in the cooler, they are dipped in 8000 ppm IBA talc as they are placed into the rooting medium. We use straight pumice as the rooting medium for all but the *Taxus*, which performs better for us in perlite.

SUMMING UP

1) **Use a Split Application of Rooting Compound, or "Double Dip" on Difficult Conifers.** Rather than treat with a higher single application of auxin, we dip difficult-to-root cuttings in a 1 : 10 dilution of Wood's Rooting Hormone and water (approximately 1000 ppm IBA and 600 ppm NAA) as the cuttings are made, and treat again with an 8000 ppm IBA talc while sticking in flats. The liquid dip provides immediate absorption of auxins by the plant tissue, and the talc treatment provides a long-term release of hormone to the cuttings. We use this method for rooting *C. obtusa*, ×*C. leylandii*, a few *Juniperus*, *P. mugo*, *T. baccata*, and the *Tsuga* species.
2) **Use an Exceptionally Well-drained Media.** Over-zealous misting can very easily waterlog rooting media and cause cuttings to rot.

Horticultural grade pumice or perlite provide excellent pore space and moisture retention without becoming waterlogged. This provides an extra measure of safety in finding the right balance, or when plants with different moisture tolerance share the same bed. They are also excellent media for bare-rooting cuttings, as a gentle tug will lift even very well rooted plants from the media. We use pumice for almost all crops that we produce. Of the conifers, *Taxus* seems to perform better in perlite.

3) **Don't Stick Cuttings too Deep!** Placing cuttings too deep in the rooting media is responsible for more losses at Mitsch Nursery than almost any other error. We like to see coniferous cuttings stuck to a depth of about 3/8 inches. The conifers that we consider the most difficult tend to callus at the bottom and root from the callus rather than send out multiple roots from the sides of the stem, so deep placement can interfere with ideal moisture and oxygen levels, and gains no advantage for stem rooting, as we would see in herbaceous or greenwood cuttings.
4) **Don't Make Cuttings too Large.** The proper placement of cuttings in the media also dictates the size of the cuttings. This is particularly important in *C. obtusa*, where it is tempting to make cuttings that are large and top-heavy. Heavy cuttings are easily dislodged from the media if they're not stuck deeper, but again, deep placement interferes with callusing and rooting. The same error is easy to make if *C. obtusa* cuttings are made with the stems longer than about 1/2 inch. The tendency is to stick the entire stem, so a shorter stem helps avoid depth problems. If trimming tops is necessary to balance the size of the cutting, trim diagonally up one side rather than straight across the top, so that new growth will more easily form a leader.
5) **Alternative Methods of Maintaining Humidity.** While active misting is absolutely necessary in the high temperatures of our summer propagation house, we apply much less moisture in the cool winter propagation house. Remember that our winter house provides 72 ºF for bottom heat, but air temperatures range in the vicinity of 40 ºF. In recent years we have found that we can maintain satisfactory humidity levels by draping a bonded agricultural cloth such as Remay directly over the propagation flats. As the bottom heat causes moisture in the rooting media to evaporate and rise, it helps to maintain the vapor in the vicinity of the cuttings. It is easily lifted and folded off the beds for overhead irrigation and breaths to allow air exchange to the cuttings. With care, the same cloth can be used for several years. We have found it to be a useful tool in rooting plants that may need careful maintenance of the rooting environment for several months.
6) **Warm Bottoms and Cool Tops for Winter-rooted Conifers.** Bottom heat applied near 75 ºF is necessary to allow cell division, callusing, and rooting. But warmer air temperatures and long day-length can encourage buds to push and grow before roots have formed. Cool air temperatures help to keep buds dormant.
7) **Patience!** Ideally, conifer cuttings that are started during the winter are ready for planting out in April or May. This may mean maintenance of temperatures and humidity through up to 5 months, and through a range of outdoor conditions that may influence the greenhouse.